Cosmology Review III

1. Cosmic Background Radiation
    a. Experiments – Boomerang, COBE, WMAP
    b. Results
        i. Blackbody spectrum
        ii. Dipole distortion (motion of COBE, Earth, Sun, Galaxy, Local group motions)
        iii. Temperature fluctuations
        iv. Multipoles and spherical harmonics
    c. Baryon to photon ratio $\eta = 5\times10^{-5}$
    d. (Radiative) Recombination epoch ($z = 1370, T = 3740K, t = 240,000\,yr$)

    $p + e^- \leftrightarrow H + \gamma$
    e. Photon decoupling ($z = 1100, T = 3000K, t = 350,000\,yr$)

    Thomson scattering $\lambda + e^- \leftrightarrow \gamma + e^-$
    f. Mean free path $\Gamma = n_e \sigma_e c$
    g. Last scattering surface
    h. Fractional ionization, *X*
2. Big Bang Nucleosynthesis
    a. Know timeline (Blackboard figure)
    b. Binding energy per nucleon
    c. Binding energies $p + e^- \leftrightarrow H + 13.6\text{eV}$ $p + n \leftrightarrow D + 2.22\text{MeV}$
    d. $T_{nuc} = 6\times10^8\,K, t_{nuc} = 300s$
    e. He fraction, Y – primordial 24%, max 1/3
    f. Beta decay $n \rightarrow p + e^- + \overline{\nu}_e$ ($\tau_n = 890s$) Binding energy – compute from difference in rest energies
    g. Beyond Deuterium – what about other elements?
    h. Baryon-antibaryon asymmetry
3. Inflation
    a. What is inflation?
    b. Know key problems – Flatness, Horizon, Monopole
    c. Standard Model of Particle Physics – Glashow, Weinberg, Salam, Gell-Mann, Higgs Quarks, Baryons, Mesons, Bosons (photons, gluons, W, Z), Leptons
    d. Symmetry breaking, Higgs mechanism (gives mass) Mexican Hat
    e. Phase transitions (loss of symmetry) and unification of forces. See Figure 11 and blackboard rendition online – including energy, temperature and time scales, electroweak, GUT and TOE, QED, QCD
    f. Topological defects
    g. General model of inflation – simple case $a(t) = \begin{cases} a_i \left(t / t_i\right)^{1/2} & t < t_i \\ a_i e^{H_i (t - t_i)} & t_i < t < t_f \\ a_i \left(t / t_f\right)^{1/2} e^{H_i (t_f - t_i)} & t > t_f \end{cases}$
    h. Number of e-foldings, $N = H_i (t_f - t_i)$
4. Alternate Theories